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(71) Applicant
Optische Werke G Rodenstock (FR Germany),
Isartalstrasse 43, 8000 Munich 5, Federal Republic of Germany

(72) Inventor
Ernst Rothe

(74) Agent and/or Address for Service
Reddie & Grose,
16 Theobalds Road, London WC1X 8PL

(54) Scanning lens arrangement having three lenses

(57) A scanning lens arrangement having three feestanding lenses of which the first lens (1), in the direction of the beam impinging on the scanning surface (5), is a positive lens, the second (2) is a meniscus lens which is concave towards the first lens, and the third (3) is a positive lens whose surface (r6) which is towards the scanning surface is concave or planar. The lens arrangement according to the invention is distinguished in that the ratios of the focal length f1 of the first lens to the overall focal length f of the lens arrangement and the focal length f3 of the third lens lie in a range whose corner points are defined by the following pairs of values (f1/f; f1/f3):

(1.570; 1.270)–(1.870; 1.295)
(1.725; 1.450)–(1.930; 1.495)

or

(1.550; 1.080)–(1.680; 1.120)
(1.580; 1.200)–(1.700; 1.240)

and that the air gaps d2 between the first and second lenses and d4 between the second and third lenses comply with the following relationships:

$0.065 \leq (d2 + d4)/f \leq 0.120$
$0.85 \leq d2/d4 \leq 5.0$

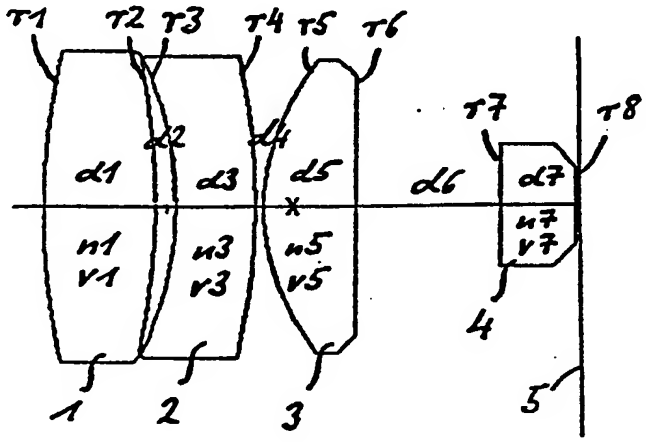

Fig. 1

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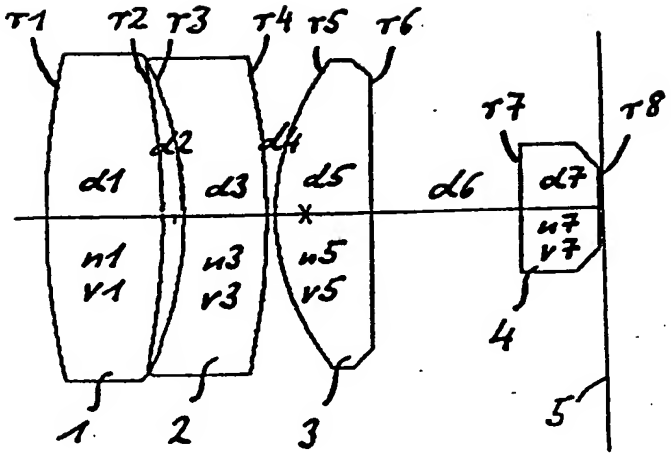

Fig. 1

SPECIFICATION

Scanning lens arrangement having three lenses

The invention relates to a scanning lens arrangement having three freestanding lenses, in accordance with the classifying portion of claims 1 and 2 respectively.

Scanning lens arrangement which are used at the present time in video disc players, 'Compactdisc (CD)' players or optical storage systems have four or more lenses. However, for reasons of cost it would be desirable to use scanning lens arrangements having only three lenses.

Proposals for scanning lens arrangements having only three lenses are disclosed in German laid-open applications (DE-OS) Nos 25 32 787, 27 03 823, 28 48 685, 29 25 737 and 31 34 001.

In the case of the scanning lens arrangements disclosed in DE-OS Nos 25 32 787 and 29 25 737, the first and second lenses, in the direction of the beam which impinges on the scanning surface (storage medium) are cemented together. As a cemented member of that kind is comparatively expensive, lens arrangements of that kind give only small savings in cost, in comparison with scanning lens arrangements having four freestanding lenses.

Scanning lens arrangements having three freestanding lenses, in accordance with the classifying portion of claims 1 and 2 respectively, are known from the other publications referred to above.

In the case of the scanning lens arrangements disclosed in DE-OS Nos 27 03 823 and 28 48 685, the order of magnitude of the air gap between the second and third lenses (as considered in the direction of the scanning beam which impinges on the scanning surface) is about 0.7 to 1.0 times the focal length of the lens arrangement and is therefore comparatively large. Although that provides the desired good correction in respect of image defects and in particular astigmatism, the intercept length of the lens arrangement is not as large as would be desirable in some situations of use.

In the lens arrangement disclosed in DE-OS Nol 31 34 001, the air gap between the second and third lenses is smaller than in the lens arrangements discussed above. However, image defects, in particular astigmatism, are not corrected in the manner that is often required, in that lens arrangement.

The invention is based on the problem of providing a scanning lens arrangement which is inexpensive to produce and which, with a large intercept length, has good image defect correction.

In accordance with the invention, that problem is solved in that the basic starting point is a scanning lens arrangement as set forth in the classifying portion of claims 1 and 2 respectively, and the conditions recited in accordance with the invention inthe characterising portions of claims 1 and 2 respectively are fulfilled. By virtue of combining the conditions in accordance with the invention, the invention provides that, in a scanning lens arrangement with three freestanding lenses, it is possible to have small air gaps and thus a large intercept length, with excellent image defect correction. In particular, spherical aberration and coma of the third and fifth orders are corrected. Astigmatism is also corrected in the manner required by the situations of use of a scanning lens arrangement.

In addition, it was surprisingly found that, in a scanning lens arrangement in which the conditions specified in accordance with the invention are fulfilled, conventional production tolerances or other deviations do not have such a large influence on image qualtiy as is the case with known lens arrangements.

However, a factor of crucial significance from the point of view of solving the problem of the invention, and the other excellent properties of the scanning lens arrangements according to the invention, is that all conditions in accordance with the invention are fulfilled. In particular, it is important that the conditions in regard to the ratios of the focal length f1 of the first lens to the overall focal length of the scanning lens arrangement and the focal length f3 of the third lens are fulfilled at the same time. If only one of the specified limits is exceeded, it is no longer possible to maintain the correction condition which distinguishes the scanning lens arrangements according to the invention, or to obtain the comparatively high degree of insensitivity in respect of tolerances.

Further developments of the invention are set forth in the subsidiary claims.

Claims 3 to 13 recite advantageous limitations in respect of the ranges set forth in claims 1 or 2. The good properties of the lens arrangements according to the invention are further enhanced thereby.

By selection of the radii in accordance with one of claims 14 and the following claims, the production costs of the lens arrangements according to the invention are further reduced.

The invention is described in greater detail hereinafter by means of embodiment, with reference to the drawing in which:

Figure 1 shows a sectional view of a scanning lens arrangement according to the invention.

The scanning arrangement comprises three freestanding lenses 1, 2 and 3. A plane-parallel glass plate 4 covers a scanning surface 5, for example a video disc or a 'Compactdisc'. The glass plate 4 is advantageously incorporated into correction of the lens arrangement.

The radii of curvature of the individual surfaces of the lens arrangement are denoted by ri ($i = 1..8$), the lens thicknesses or air gaps are denoted by di, the refractive indexes of the lenses are denoted by ni and Abbe number is denoted by vi.

Tables 1–5 set forth values in respect of those parameters for different embodiments. The embodiments are monochromatically corrected for wavelengths from the range of about 750 nm to about 850 nm. Therefore, the refractive indexes ni are specified for the wavelength of 800 nm. The Abbe numbers which are given only for the sake of completeness, by virtue of the monochromatic correction action, apply in respect of the e-line.

The Tables also include the values of the ratios of the focal length f1 of the first lens 1 to the overall focal length f of the scanning lens arrangement and the focal length f3 of the third lens, as well as the sums, related to the focal length of the total lens arrangement, of the air gaps d2 between the first and second lenses and d4 between the second and third lenses, as well as the ratios between those air gaps.

In Tables 1 to 5, the overall focal length f is standardised in each case at 1. Scanning lens arrangements which are actually produced have a focal length f between about 4 and 10 mm, with an aperture ratio of between 1:0.85 and 1:1.5, and an image angle of about 0.5–2°.

Tables 1 and 2 set forth various embodiments in which the values in respect of f1/f, f1/f3, (d2 + d4)/f and d2/d4 cover the ranges specified in accordance with the invention.

Tables 3 and 4 are intended to demonstrate that the conditions specified in accordance with the invention actually represent a universal design principle for scanning lens arrangements in accordance with the classifying portions of claims 1 and 2 respectively.

In Table 3, the value for the ratio of the focal length f1 to the overall focal length f of the scanning lens arrangement is kept substantially constant at a value of 1.724. As can be readily seen, even if a value is fixed beforehand, it is possible to provide scanning lens arrangements with a good correction action, which solve the problem set in accordance with the invention and which also have the further advantages of the solution according to the invention, wherein the other values vary within the ranges specified in accordance with this invention. For example, the ratio f1/f3 goes through the range of from about 1.3 to 1.45.

In Table 4, in addition to the f1/f, the values (d2 + d4)/f and d2/d4 are kept substantially constant. However, it is possible to provide scanning lens arrangements in which the value in respect of f1/f3 passes through the entire range according to the invention.

It is therefore evident that the conditions specified in accordance with the invention are a genuine design principle which readily permits the average man skilled in the art to design scanning lens arrangements with three freestanding lenses in accordance with the classifying portion of claims 1 and 2 respectively, in such a way that, with a large intercept length (and thus a short design length), the lens arrangement provides excellent correction of image defects and is also insensitive to constructional tolerances.

Table 1

Nr.	1	2	3	4	5	6
r 1 =	1.860	1.485	1.493	1.666	1.717	1.660
d 1 =	0.400	0.400	0.400	0.327	0.345	0.327
n 1 =	1.78	1-78	1.64	1.77	1.64	1.77
v 1 =	47.2	47.2	55.6	36.83	55.62	36.83
r 2 =	−3.314	−6.716	−3.398	−5.194	−2.760	−5.773
d 2 =	0.047	0.068	0.071	0.072	0.052	0.071
r 3 =	−1.522	−1.483	−1.364	−1.567	−1.330	−1.629
d 3 =	0.300	0.300	0.300	0.266	0.334	0.267
n 3 =	1.71	1.71	1.77	1.77	1.77	1.77
v 3 =	28.5	28.5	25.9	25.87	25.87	25.87
r 4 =	−5.187	−3.849	−2.787	−3.637	−2.523	−3.579
d 4 =	0.030	0.030	0.030	0.036	0.044	0.036
r 5 =	0.801	0.806	0.812	0.823	0.842	0.832
d 5 =	0.400	0.200	0.350	0.400	0.222	0.472
n 5 =	1.64	1.64	1.64	1.64	1.64	1.64
v 5 =	55.6	55.6	55.6	55.62	55.62	55.62
r 6 = ∞		r 6 = ∞	r 6 = ∞	r 6 = ∞	r 6 = ∞	r 6 = ∞
d 6 =	0.500	d 6 = 0.500	d 6 = 0.195	d 6 = 0.390	d 6 = 0.445	d 6 = 0.345
r 7 = ∞		r 7 = ∞	r 7 = ∞	r 7 = ∞	r 7 = ∞	r 7 = ∞
d 7 =	0.300	d 7 = 0.300	d 7 = 0.300	d 7 = 0.305	d 7 = 0.267	d 7 = 0.305
n 7 =	1.51	n 7 = 1.51	n 7 = 1.51	n 7 = 1.51	n 7 = 1.55	n 7 = 1.51
v 7 =	64.1	v 7 = 64.1	v 7 = 64.1	v 7 = 64.08	v 7 = 44.95	v 7 = 64.08
r 8 = ∞		r 8 = ∞	r 8 = ∞	r 8 = ∞	r 8 = ∞	r 8 = ∞
f1/f = 1.587		f1/f = 1.600	f1/f = 1.667	f1/f = 1.675	f1/f = 1.697	f1/f = 1.710
f1/f3 = 1.274		f1/f3 = 1.276	f1/f3 = 1.319	f1/f3 = 1.309	f1/f3 = 1.296	f1/f3 = 1.321
(d2 + d4)/f = 0.077		(d2 + d4)/f = 0.098	(d2 + d4)/f = 0.101	(d2 + d4)/f = 0.108	(d2 + d4)/f = 0.096	(d2 + d4)/f = 0.107
d2/d4 = 1.55		d2/d4 = 2.28	d2/d4-2.37	d2/d4 = 1.99	d2/d4 = 1.17	d2/d4 = 1.96

Table 1 (Cont., I)

Nr	7	8	9	10	11	12
r 1 =	2.297	2.297	2.055	2.169	1.875	1.878
d 1 =	0.321	0.321	0.401	0.400	0.320	0.321
n 1 =	1.77	1.77	1.87	1.78	1.78	1.78
v 1 =	36.8	36.8	40.8	47.2	47.2	47.2
r 2 =	−2,923	−2.923	−4.999	−3.217	−4.478	−4.485
d 2 =	0.065	0.065	0.060	0.055	0.072	0.072
r 3 =	−1.325	−1.325	−1.516	−1.374	−1.376	−1.378
d 3 =	0.200	0.200	0.301	0.300	0.200	0.200
n 3 =	1.77	1.77	1.71	1.71	1.77	1.77
v 3 =	25.9	25.9	28.5	28.5	25.9	25.9
r 4 =	−2.790	−2.790	−3.622	−2.573	−2.785	−2.770
d 4 =	0.030	0.030	0.030	0.030	0.020	0.020
r 5 =	0.821	0.821	0.809	0.745	0.825	0.827
d 5 =	0.401	0.578	0.401	0.400	0.340	0.521
n 5 =	1.64	1.64	1.64	1.56	1.64	1.64
v 5 =	55.6	55.6	55.6	60.6	55.6	55.6
r 6 = ∞		r 6 = ∞	r 6 = ∞	r 6 = ∞	r 6 = ∞	r 6 = ∞
d 6 =	0.481	d 6 = 0.496	d 6 = 0.501	d 6 = 0.500	d 6 = 0.506	d 6 = 0.514
r 7 = ∞		r 7 = ∞	r 7 = ∞	r 7 = ∞	r 7 = ∞	r 7 = ∞
d 7 =	0.240	d 7 = 0.060	d 7 = 0.301	d 7 = 0.300	d 7 = 0.240	d 7 = 0.060
n 7 =	1.49	n 7 = 1.51	n 7 = 1.51	n 7 = 1.51	n 7 = 1.55	n 7 = 1.55
v 7 =	66.8	v 7 = 60.2	v 7 = 64.1	v 7 = 64.1	v 7 = 45.0	v 7 = 45.0
r 8 = ∞		r 8 = ∞	r 8 = ∞	r 8 = ∞	r 8 = ∞	r 8 = ∞
f1/f = 1.719		f1/f = 1.719	f1/f = 1.720	f1/f = 1.723	f1/f = 1.739	f1/f = 1.742
f1/f3 = 1.346		f1/f3 = 1.346	f1/f3 = 1.367	f1/f3 = 1.289	f1/f3 = 1.355	f1/f3 = 1.355
(d2 + d4)/f = 0.95		(d2 + d4/f = 0.095	(d2 + d4)/f = 0.090	(d2 + d4)/f = 0.085	(d2 + d4)/f = 0.092	(d2 + d4/f = 0.092
d2/d4 = 2.16		d2/d4 = 2.16	d2/d4 = 2.00	d2/d4 = 1.84	d2/d4 = 3.59	d2/d4 = 3.59

Table 1 (Cont., II)

Nr	13	14	15	16	17	18
r 1 =	2.625	2.268	2.078	1.767	1.941	2.035
d 1 =	0.399	0.401	0.471	0.376	0.300	0.400
n 1 =	1.78	1.87	1.78	1.77	1. 78	1.78
v 1 =	47.15	40.76	47.2	36.83	47.2	47.2
r 2 =	−2.625	−4.248	−3.539	−5.506	−4.523	−4.779
d 2 =	0.073	0.070	0.070	0.083	0.063	0.071
r 3 =	−1.220	−1.314	−1.379	−1.449	−1.427	−1.328
d 3 =	0.288	0.200	0.314	0.267	0.300	0.300
n 3 =	1.77	1.77	1.77	1.77	1.77	1.71
v 3 =	25.87	25.87	25.9	25.87	25.9	28.5
r 4 =	−2.357	−2.286	−2.702	−2.711	−2.641	−2.245
d 4 =	0.031	0.020	0.036	0.036	0.030	0.030
r 5 =	0.818	0.821	0.010	0.818	0.845	0.827
d 5 =	0.324	0.401	0.399	0.400	0.400	0.400
n 5 =	1.65	1.58	1.65	1.64	1.64	1.64
v 5 =	50.59	61.03	50.6	55.62	55.6	55.6
r 6 = ∞		r 6 = 10.096	r 6 = ∞	r 6 = ∞	r. 6 = ∞	r 6 = ∞
d 6 =	0.507	d 6 = 0.501	d 6 = 0.388	d 6 = 0.388	d 6 = 0.500	d 6 = 0.500
r 7 = ∞		r 7 = ∞	r 7 = ∞	r 7 = ∞	r 7 = ∞	r 7 = ∞
d 7 =	0.266	d 7 = 0.301	d 7 = 0.305	d 7 = 0.305	d 7 = 0.300	d 7 = 0.300
n 7 =	1.51	n 7 = 1.51	n 7 = 1.51	n 7 = 1.51	n 7 = 1.51	n 7 = 1.51
v 7 =	60.15	v 7 = 64.08	v 7 = 60.2	v 7 = 64.08	v 7 = 64.1	v 7 = 64.1
r 8 = ∞		r 8 = ∞	r 8 = ∞	r 8 = ∞	r 8 = ∞	r 8 = ∞
f1/f = 1.747		f1/f = 1.749	f1/f = 1.749	f1/f = 1.779	f1/f = 1.787	f1/f = 1.888
f1/f3 = 1.386		f1/f3 = 1.322	f1/f3 = 1.402	f1/f3 = 1.399	f1/f3 = 1.360	f1/f3 = 1.468
(d2/d4)/f = 0.104		(d2 + d4)/f = 0.09	(d2 + d4)f = 0.106	(d2 + d4)/f = 0.119	(d2 + d4)/f = 0.093	(d2 + d4)/f = 0.101
d2/d4 = 2.36		d2/d4 = 3.48	d2/d4 = 1.93	d2/d4 = 2.29	d2/d4 = 2.09	d2/d4 = 2.38

Table 2

No	19	20	21	22	23
r 1 =	1.548	1.278	1.797	1.677	1 708
d 1 =	0.367	0.400	0.301	0.400	0.300
n 1 =	1.64	1.56	1.87	1.78	1.78
v 1 =	55.6	60.6	40.8	47.2	47.2
r 2 =	−2.713	−2.682	−6.842	−5.084	−4.921
d 2 =	0.050	0.053	0.053	0.083	0.050
r 3 =	−1.208	−1.305	−1.800	−1.400	−1.696
d 3 =	0.234	0.300	0.200	0.300	0.200
n 3 =	1.77	1.61	1.77	1.77	1.77
v 3 =	25.9	36.1	25.9	25.9	25.9
r 4 =	−2.350	−2.491	−4.166	−2.399	−3.645
d 4 =	0.033	0.030	0.020	0.030	0.020
r 5 =	0.679	0.770	0.771	0.690	0.769
d 5 =	0.334	0.500	0.401	0.300	0.400
n 5 =	1.51	1.56	1.58	1.51	1.58
v 5 =	64.1	60.6	61.0	64.1	61.0
r 6 = ∞		r 6 = ∞	r 6 = 11.900	r 6 = ∞	r 6 = 10.527
d 6 =	0.601	d 6 = 0.500	d 6 = 0.501	d 6 = 0.195	d 6 = 0.500
r 7 = ∞		r 7 = ∞	r 7 = ∞	r 7 = ∞	r 7 = ∞
d 7 =	0.050	d 7 = 0.300	d 7 = 0.301	d 7 = 0.300	d 7 = 0.300
n 7 =	1.51	n 7 = 1.51	n 7 = 1.51	n 7 = 1.51	n 7 = 1.51
v 7 =	61.0	v 7 = 64.1	v 7 = 64.1	v 7 = 64.1	v 7 = 64.1
r 8 = ∞		r 8 = ∞	r 8 = ∞	r 8 = ∞	r 8 = ∞
f1/f = 1.586		f1/f = 1.612	f1/f = 1.663	f1/f = 1.666	f1/f = 1.667
f1/f3 = 1.194		f1/f3 = 1.167	f1/f3 = 1.189	f1/f3 = 1.233	f1/f3 = 1.187
(d2 + d4)/f = 0.083		(d2 + d4/f = 0.083	(d2 + d4)/f = 0.073	(d2 + d4)/f = 0.113	(d2 + d4)/f = 0.070
d2/d4 = 1.49		d2/d4 = 1.75	d2/d4 = 2.64	d2/d4 = 2.76	d2/d4 = 2.50

Table 3

Nr	24	25	26	27	28	29
r 1 =	2.595	2.092	2.146	2.181	1.741	2.054
r 1 =	0.400	d 1 = 0.400	d 1 = 0.400	d 1 = 0.400	d 1 = 0.400	r 1 = 0.400
n 1 =	1.78	n 1 = 1.78	n 1 = 1.78	n 1 = 1.78	n 1 = 1.64	n 1 = 1.78
v 1 =	47.2	v 1 = 47.2	v 1 = 47.2	v 1 = 47.2	v 1 = 54.5	v 1 = 47.2
r 2 =	−2.576	r 2 = −3.411	r 2 = −3.268	r 2 = −3.187	r 2 = −2.777	r 2 = −3.520
d 2 =	0.054	d 2 = 0.042	d 2 = 0.053	d 2 = 0.042	d 2 = 0.046	d 2 = 0.055
r 3 =	−1.268	r 3 = −1.635	r 3 = −1.407	r 3 = −1.571	r 3 = −1.410	r 3 = −1.426
d 3 =	0.300	d 3 = 0.300	d 3 = 0.500	d 3 = 0.300	d 3 = 0.300	d 3 = 0.300
n 3 =	1.71	n 3 = 1.71	n 3 = 1.71	n 3 = 1.71	n 3 = 1.71	n 3 = 1.71
v 3 =	28.5	v 3 = 28.5	v 3 = 28.5	v 3 = 28.5	v 3 = 28.5	v 3 = 28.5
r 4 =	−2.425	r 4 = −4.260	r 4 = −2.761	r 4 = −3.3833	r 4 = −3.049	r 4 = −3.123
d 4 =	0.030	d 4 = 0.030	d 4 = 0.030	d 4 = 0.030	d 4 = 0.030	d 4 = 0.030
r 5 =	0.736	r 5 = 0.737	r 5 = 0.829	r 5 = 0.826	r 5 = 0.821	r 5 = 0.820
d 5 =	0.400	d 5 = 0.400	d 5 = 0.400	d 5 = 0.600	d 5 = 0.500	d 5 = 0.400
n 5 =	1.56	n 5 = 1.64	n 5 = 1.64	n 5 = 1.64	n 5 = 1.64	n 5 = 1.64
v 5 =	60.6	v 5 = 55.6	v 5 = 55.6	v 5 = 55.6	v 5 = 55.6	v 5 = 55.6
r 6 = ∞		r 6 = 5.002	r 6 = ∞	r 6 = ∞	r 6 = ∞	r 6 = ∞
d 6 =	0.500	d 6 = 0.500	d 6 = 0.500	d 6 = 0.500	d 6 = 0.500	d 6 = 0.500
r 7 = ∞		r 7 = ∞	r 7 = ∞	r 7 = ∞	r 7 = ∞	r 7 = ∞
d 7 =	0.300	d 7 = 0.300	d 7 = 0.500	d 7 = 0.300	d 7 = 0.300	d 7 = 0.300
n 7 =	1.51	n 7 = 1.51	n 7 = 1.51	n 7 = 1.51	n 7 = 1.51	n 7 = 1.51
v 7 =	64.1	v 7 = 64.1	v 7 = 64.1	v 7 = 64.1	v 7 = 64.1	v 7 = 64.1
r 8 = ∞		r 8 = ∞	r 8 = ∞	r 8 = ∞	r 8 = ∞	r 8 = ∞
f1/f = 1.724		f1/f = 1.724	f1/f = 1.725	f1/f = 1.725	f1/f = 1.724	f1/f = 1.724
f1/f3 = 1.306		f1/f3 = 1.329	f1/f3 = 1.337	f1/f3 = 1.349	f1/f3 = 1.349	f1/f3 = 1.351
(d2 + d4)/f = 0.084		(d2 + d4)/f = 0.072	(d2 + d4)/f = 0.083	(d2 + d4)/f = 0.072	(d2 + d4)/f = 0.076	(d2 + d4)/f = 0.085
d2/d4 = 1.79		d2/d4 = 1.38	d2/d4 = 1.78	d2/d4 = 1.41	d2/d4 = 1.54	d2/d4 = 1.83

Table 3 (Cont.)

Nr	30	31	32	33	34	35
r 1 =	1.717	1.669	2.264	1.845	1.830	1.712
d 1 =	0.400	0.400	0.400	0.400	0.400	0.400
n 1 =	1.78	1.78	1.78	1.78	1.78	1.78
v 1 =	47.2	47.2	47.2	47.2	47.2	47.2
r 2 =	−5.467	−6.055	−3.021	−4.425	−4.511	−5.528
d 2 =	0.062	0.065	0.053	0.065	0.059	0.063
r 3 =	−1.520	−1.509	−1.365	1.394	−1.478	−1.501
d 3 =	0.300	0.100	0.300	0.300	0.300	0.300
n 3 =	1.71	1.71	1.71	1.71	1.71	1.71
v 3 =	28.5	28.5	28.5	28.5	28.5	28.5
r 4 =	−3.312	−3.783	−3.105	−3.031	−3.444	−4.273
d 4 =	0.030	0.030	0.030	0.030	0.030	0.030
r 5 =	0.818	0.809	0.809	0.806	0.804	0.925
d 5 =	0.400	0.400	0.400	0.600	0.400	0.400
n 5 =	1.64	1.64	1.64	1.64	1.64	1.78
v 5 =	55.6	55.6	55.6	55.6	55.6	47.2
r 6 = ∞		r 6 = ∞	r 6 = ∞	r 6 = ∞	r 6 = ∞	r 6 = ∞
d 6 =	0.500	d 6 = 0.500	d 6 = 0.500	d 6 = 0.500	d 6 = 0.500	d 6 = 0.500
r 7 = ∞		r 7 = ∞	r 7 = ∞		r 7 = ∞	r 7 = ∞
d 7 =	0.300	d 7 = 0.300	d 7 = 0.300		d 7 = 0.300	d 7 = 0.300
n 7 =	1.51	n 7 = 1.51	n 7 = 1.51		n 7 = 1.51	n 7 = 1.51
v 7 =	64.1	v 7 = 64.1	v 7 = 64.1		v 7 = 64.1	v 7 = 64.1
r 8 = ∞		r 8 = ∞	r 8 = ∞		r 8 = ∞	r 8 = ∞
f1/f = 1.724		f1/f = 1.725	f1/f = 1.725	f1/f = 1.724	f1/f = 1.725	f1/f = 1.724
f1/f3 = 1.354		f1/f3 = 1.370	f1/f3 = 1.371	f1/f3 = 1.375	f1/f3 = 1.380	f1/f3 = 1.448
(d2 + d4)/f = 0.092		(d2 + d4)/f = 0.095	(d2 + d4)/f = 0.083	(d2 + d4)/f = 0.095	(d2 + d4)/f = 0.089	(d2 + d4)/f = 0.093
d2/d4 = 2.06		d2/d4 = 2.15	d2/d4 = 1.77	d2/d4 = 2.15	d2/d4 = 1.98	d2/d4 = 2.10

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Table 4

Nr	36	37	38	39	40	41
r 1 =	1.886	1.918	2.304	1.933	1.945	1.984
d 1 =	0.200	0.400	0.400	0.400	0.400	0.600
n 1 =	1.78	1.78	1.78	1.78	1.78	1.78
v 1 =	47.2	47.2	47.2	47.2	47.2	47.2
r 2 =	−4.399	−4.024	−2.955	−3.958	−3.905	−3.571
d 2 =	0.056	0.057	0.056	0.057	0.057	0.058
r 3 =	−1.519	−1.456	−1.319	−1.454	−1.440	−1.393
d 3 =	0.300	0.300	0.300	0.300	0.300	0.300
n 3 =	1.71	1.83	1.71	1.71	1.61	1.71
v 3 =	28.5	23.6	28.5	28.5	36.1	28.5
r 4 =	−3.417	−2.838	−2.636	−3.290	−4.068	−3.173
d 4 =	0.030	0.030	0.030	0.030	0.030	0.030
r 5 =	0.855	0.823	0.930	0.812	0.800	0.771
d 5 =	0.400	0.400	0.600	0.400	0.400	0.400
n 5 =	1.64	1.64	1.64	1.64	1.64	1.64
v 5 =	55.6	55.6	55.6	55.6	55.6	55.6
r 6 = ∞		r 6 = ∞	r 6 =	−5.002	r 6 = ∞	r 6 = ∞
d 6 =	0.500	d 6 = 0.500	d 6 =	0.500	d 6 = 0.500	d 6 = 0.500
r 7 = ∞		r 7 = ∞	r 7 = ∞		r 7 = ∞	r 7 = ∞
d 7 =	0.300	d 7 = 0.300	d 7 =	0.300	d 7 = 0.300	d 7 = 0.300
n 7 =	1.51	n 7 = 1.51	n 7 =	1.51	n 7 = 1.51	n 7 = 1.51
v 7 =	64.1	v 7 = 64.1	v 7 =	64.1	v 7 = 64.1	v 7 = 64.1
r 8 = ∞		r 8 = ∞	r 8 = ∞		r 8 = ∞	r 8 = ∞
f1/f = 1.725		f1/f = 1.724	f1/f = 1.724		f1/f = 1.725	f1/f = 1.725
f1/f3 = 1.297		f1/f3 = 1.348	f1/f3 = 1.358		f1/f3 = 1.366	f1/f3 = 1.387
(d2 + d4)/f = 0.086		(d2 + d4)/f = 0.087	(d2 + d4)/f = 1.086		(d2 + d4)/f = 0.087	(d2 + d4)/f = 0.087
d2/d4 = 1.87		d2/d4 = 1.91	d2/d4 = 1.86		d2/d4 = 1.90	d2/d4 = 1.91

CLAIMS

1. A scanning lens arrangement having three freestanding lenses of which the first lens (1), in the direction of the beam impinging on the scanning surface, is a positive lens, the second (2) is a negative meniscus lens which is concave towards the first lens, and third (3) is a positive lens whose surface which is towards the scanning surface is concave or planar, characterised in that the ratios of the focal length f1 of the first lens to the overall focal length f of the lens arrangement and the focal length f3 of the third lens lie in a range whose corner points form the following pairs of values (f1/f; f1/f3):

(1.570; 1.270) – (1.870; 1.295)
| |
(1.725; 1.450) – (1.930; 1.495)

and that the air gaps d2 between the first and second lenses and d4 between the second and third lenses comply with the following relationships:

$0.065 \leq (d2 + d4)/f \leq 0.120$
$0.85 \leq d2/d4 \leq 5.0.$

2. A scanning lens arrangement having three freestanding lenses of which the first lens (1), in the direction of the beam impinging on the scanning surface, is a positive lens, the second (2) is a negative meniscus lens which is concave towards the first lens, and the third (3) is a positive lens whose surface which is towards the scanning surface is concave or planar, characterised in that the ratios of the focal length f1 of the first lens to the overall focal length f of the lens arrangement and the focal length f3 of the third lens lie in a range whose corner points form the following pairs of values (f1/f; f1/f3):

(1.550; 1.080) – (1.680; 1.120)
| |
(1.580; 1.200) – (1.700; 1.240)

and that the air gaps d2 between the first and second lenses and d4 between the second and third lenses comply with the following relationships:

$0.065 \leq (d2 + d4)/f \leq 0.120$
$0.85 \leq d2/d4 \leq 5.0.$

3. A scanning lens arrangement according to claim 1 or claim 2 characterised in that the condition:

$1.180 \leq f3/f \leq 1.390$

is fulfilled.

4. A scanning lens arrangement according to claim 1 or claim 2 characterised in that the condition:

$1.240 \leq f3/f \leq 1.320$

is fulfilled.

5. A scanning lens arrangement according to claim 1 or claim 2 characterised in that the condition:

$1.260 \leq f3/f \leq 1.300$

is fulfilled.

6. A scanning lens arrangement according to one of claims 1, 3, 4 or 5 characterised in that the condition:

$1.280 \leq f1/f3 \leq 1.375$

is fulfilled.

7. A scanning lens arrangement according to one of claims 1, 3, 4 or 5 characterised in that the condition:

$1.295 \leq f1/f3 \leq 1.365$

is fulfilled.

8. A scanning lens arrangement according to one of claims 1 or 3 to 7 characterised in that the condition:

$1.680 \leq f1/f \leq 1.820$

is fulfilled.

9. A scanning lens arrangement according to one of claims 1 or 3 to 7 characterised in that the condition:

$1.710 \leq f1/f \leq 1.800$

is fulfilled.

10. A scanning lens arrangement according to one of claims 1 or 3 to 7 characterised in that the condition:

$1.720 \leq f1/f \leq 1.795$

is fulfilled.

11. A scanning lens arrangement according to one of claims 1 to 10 characterised in that the condition:

$1.5 \leq d2/d4 \leq 4.0$

is fulfilled.

12. A scanning lens arrangement according to one of claims 1 to 10 characterised in that the condition:

$2.0 \leq d2/d4 \leq 3.5$

is fulfilled.

13. A scanning lens arrangement according to one of claims 2 to 5 or 11, 12 characterised in that the condition:

$1.600 \leq f1/f \leq 1.670$

is fulfilled.

14. A scanning lens arrangement according to one of claims 1 to 13 characterised in that the radii r1–r4 fulfil the condition:
$1.2f \leq |r1| \ldots |r4| \leq 7.0f$.

15. A scanning lens arrangement according to one of claims 1 to 13 characterised in that the radii r1–r4 fulfil the condition:
$1.3f \leq |r1| \ldots |r4| \leq 5.5f$.

16. A scanning lens arrangement according to one of claims 1 to 13 characterised in that the radii r1–r4 fulfil the condition:
$1.4f \leq |r1| \ldots |r4| \leq 4.5f$.

17. A scanning lens arrangement according to one of claims 1 to 16 characterised in that the radius r5 fulfills the condition:
$0.6f \leq r5 \leq 0.95f$.

18. A scanning lens arrangement according to one of claims 1 to 16 characterised in that the radius r5 fulfills the condition:
$0.75f \leq r5 \leq 0.88f$.

19. A scanning lens arrangement according to one of claims 1 to 16 characterised in that the radius r5 fulfils the condition:
$r5 = (0.82 \pm 0.025)f$.

20. A scanning lens arrangement according to one of claims 1 to 19 characterised in that the radius r2 fulfills the condition:
$|r2| \geq 2.8f$.

21. A scanning lens arrangement according to one of claims 1 to 19 characterised in that the absolute values of the radii of curvature of the two surfaces of the first lens are approximately equal.

22. A scanning lens arrangement according to one of claims 1 to 21 characterised in that the edge of the first surface (r3) of the second lens (2) bears against the second surface (r2) of the first lens (1).

23. A scanning lens arrangement according to one of claims 1 to 22 characterised in that

the plane-parallel plate (4) is incorporated into the correction.

24. A scanning lens arrangement according to one of claims 1 to 21 characterised by design data ri, di, ni, in accordance with one of embodiments 1–41.

25. A scanning lens arrangement according to claim 24 characterised by the values of vi, in accordance with the corresponding embodiment.

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